Vacuum Assisted Resin Transfer Molding

A Rapid, Low Cost Manufacturing Technique for *Predator* Components

To General Atomics: 23/24 May 2002

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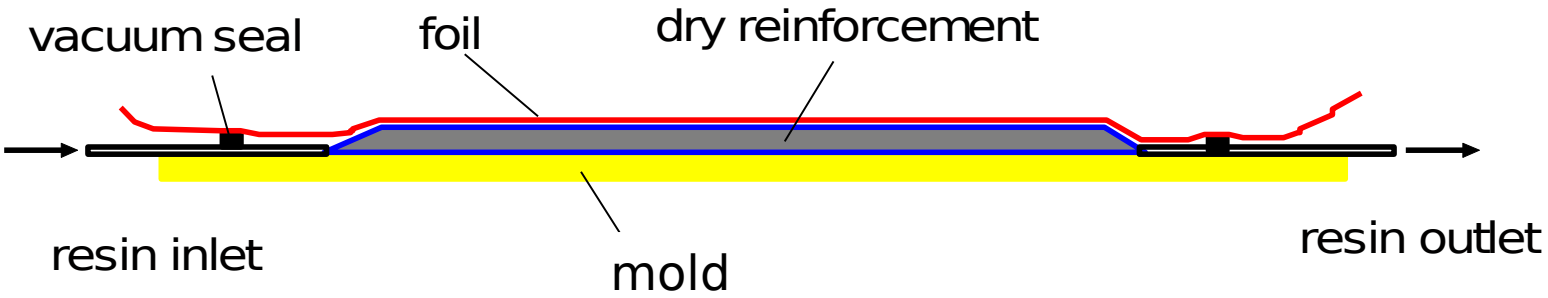
Problem Description

- General Atomics *Predator* UAV
- Main structural construction: composite materials
- Major components: two 24-ft wings, fuselage, tail
  - Current fabrication method: wet lay-up
- Prototype manufacturing complete
- Full-scale production ramp-up beginning
- Potential for low production rate
  - Due primarily to time-intensive fabrication techniques
- Enlarged *Predator-B* coming on line
- Faster, less expensive manufacturing technique desired

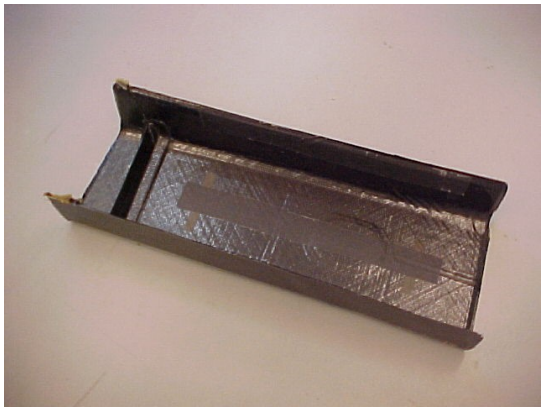
Fabrication Options

- Wet Lay-Up (“Hand Lay-Up”)
  - Pros: Simple
  - Cons: Slow, Labor Intensive, Low mechanical properties
- Autoclave Processing
  - Pros: Very high quality, Process Controllability
  - Cons: Expensive equipment and tooling
- Vacuum Assisted Resin Transfer Molding (VARTM)
  - Pros: Inexpensive, Simple Equipment & Tooling, Rapid
  - Potential Con: patented by U.S. firm for boat construction



VARTM Examples

- AIR
  - *Eagle* Rudder
  - Generic Wing Spar
  - Wind Turbine Blade
  - JASSM



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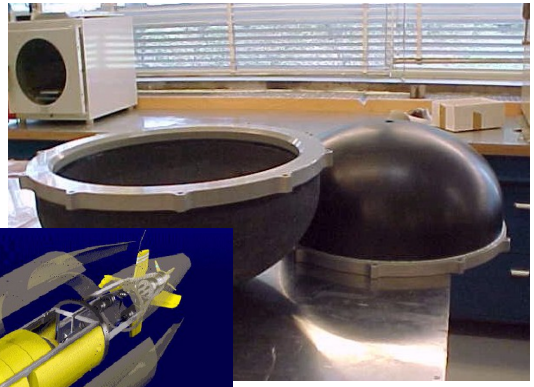
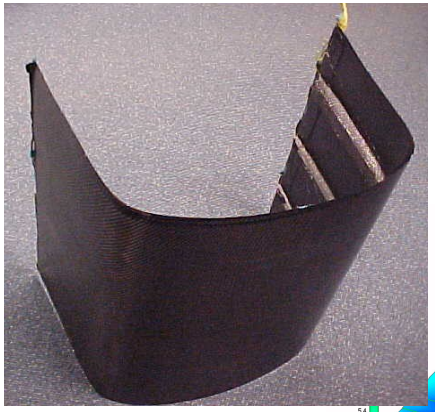
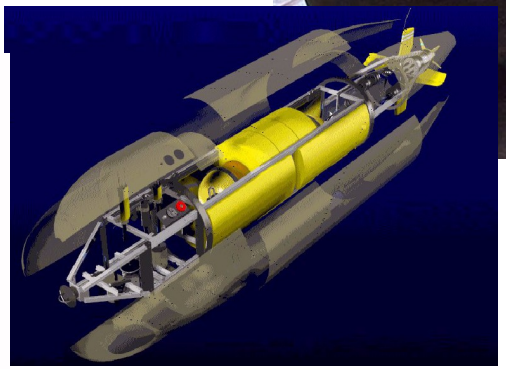
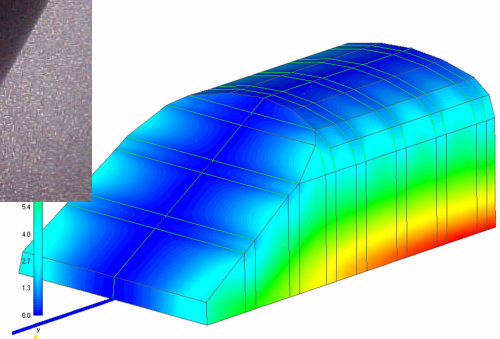
VARTM Examples

- SEA
  - *Contest 55* Hull and Upper Deck
  - Submersible Pressure Hull Ends
- SPACE
  - Ariane-5 LOX Fairing







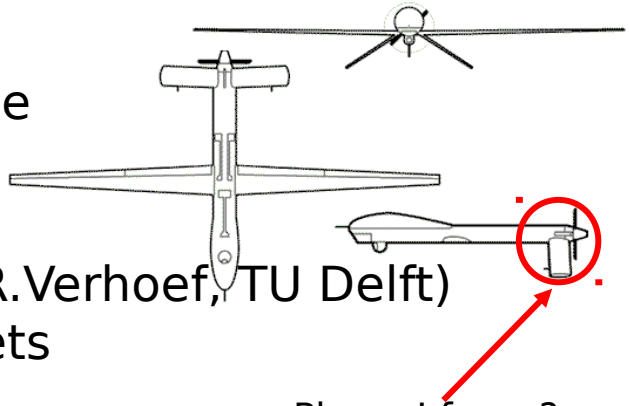


USAF Academy Proposal

- Goal
  - Assist Predator SPO and General Atomics in rapidly developing a low-cost solution to meet production schedule
- Objectives
  - Demonstrate viability of VARTM process
  - Produce small full-scale *Predator* component
  - Assist planning for scale-up of VARTM process to produce *Predator* fuselage, wings
  - Produce large full-scale *Predator* component
  - Transfer technology to General Atomics
  - Provide opportunities for USAFA cadet involvement
  - Increase international partnership with TU Delft
  - Lay groundwork for possible future CRADA

USAF Academy Proposa

- Notional Approach
  - Components
    - *Phase I:* Predator tailplane or empennage
    - *Phase II:* Predator fuselage
  - Personnel
    - New Hire: full time engineer/fabricator (R.Verhoef, TU Delft)
    - Existing USAFA faculty, technicians, cadets
  - Facilities
    - Existing lab space in USAFA Departments of Engineering Mechanics and Aeronautics
  - Equipment
    - Existing VARTM equipment
    - Some additional components
  - Support from SPO/GA
    - Funding, tech data, plans, molds



USAF Academy Proposa

- Schedule (notional)
  - Feb 02 Go-Ahead from Predator SPO
  - Jun 02 Funding Provided to USAFA
  - Sep 02 Contracting Complete/Start Phase I
  - Nov 02 Critical Design Review, Phase I
  - Jan 03 Fabrication of Phase I prototype component
  - Jan 03 Destructive Testing
  - Mar 03 Report to Program Office and General Atomics
  - Apr 03 Phase I “Production” component delivered
  - Jun 03 CDR, Phase II component
  - Aug-Oct 03 Fabrication of Phase II prototype component
  - Oct 03 Destructive testing
  - Jan 04 Redesign/modification based on test results
  - May 04 Phase II “Production” component delivered
  - Jul 04 Final report; completion of tech transfer to GA

Program Cost Estimate

- Costs
  - Engineer (2 yrs) $150K
  - TU Delft support $100K
  - Equip/Mat'ls: $ 40K
  - Travel: $ 20K
  - TOTAL: $310K

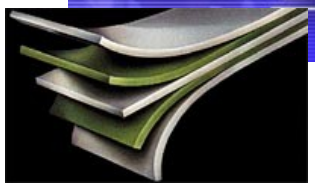
GFE: molds, tech data, drawings, etc.

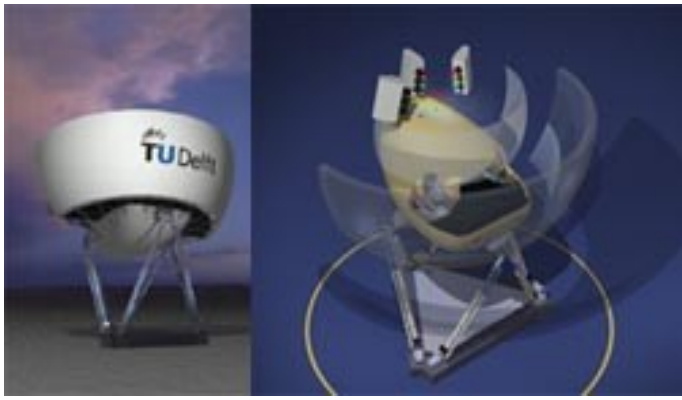
Payoffs

- Flight-ready, production-quality *Predator* components
- Demonstration of low-cost rapid VARTM fabrication technique
- Confirmation of potential for scale-up
- Big savings vs. contractor-performed work
- Involvement of USAFA faculty, staff, and cadets
- Stronger interaction with TU Delft
- Unified USAFA team
- Possible CRADA
- Tie in with JASSM & others

Disclosure Issues

- Spin-**on** of foreign-developed technology
- Long history of USAF interaction w/ TU Delft
- Foreign nationals in lab
- No classified or controlled unclassified military info to be disclosed
- Complete SAF/IAPD review process anticipated
- SPO-approved approach





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Status (as of 22 May 02)

- Funding (through ASC/RA)
  - $150K promised
  - Additional year of funding “looks good”
  - Potential tie in with AFRL Composite Affordability project
- Personnel
  - Visa work in process
  - Unlimited “reachback” to TU Delft established
- Support
  - Strong support from USAF Academy
    - Office and lab space sufficient for project
  - Strong interest from OSD
- Next Steps
  - Meet with General Atomics (R. Harris, *et al*) – 23-24 May 02
  - Meet with TU Delft staff in person – 2-4 Jun 02
  - Formalize project plan – Summer 02

Wrap-Up

USAFA ready to assist solving *Predator* production problems

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